NASA Applied Sciences Program

Extending NASA Earth-Sun System Research Results through a Systems Engineering Capacity

Guiding National Objective 5 – Study the Earth system from space and develop new space-based and related capabilities for this purpose.

Advance scientific knowledge of the Earth system through space-based observation, assimilation of new observations, and development and deployment of enabling technologies, systems, and capabilities, including those with potential to improve future operational systems. (Strategic Objective 14)

Explore the Sun-Earth system to understand the Sun and its effects on Earth, the solar system, and the space environmental conditions that will be experienced by human explorers, and demonstrate technologies that can improve future operational systems. (Strategic Objective 15)

The New Age of Exploration, NASA, February 2005

EXECUTIVE SUMMARY

NASA's Strategic Objective #14 for 2005 and beyond is to "advance scientific knowledge of the Earth system through space-based observation, assimilation of new observations, and development and deployment of enabling technologies, systems, and capabilities, including those with potential to improve future operational systems. " To address this objective, NASA needs the capacity to evaluate the potential of space-based observations, the assimilation of new observations, and the development and deployment of enabling technologies, systems, and capabilities to improve future operational systems. Because improvements to future operational systems will be implemented by NASA's agency partners who need credible evidence of value well in advance of their multi-year budget planning cycles, these evaluations must be early, rapid, and credible.

To satisfy this need, the NASA Applied Science Program of the Science Mission Directorate is developing methods and tools that will allow the research community to rapidly network for evaluation purposes NASA and partner agency capabilities that already exist or are well defined (e.g., current or near-future observing systems, modeling systems, and partner agency decision support systems). The intent is to facilitate current and future evaluations by identifying and developing a small number of methods and tools that can be rapidly and efficiently applied to a broad range of evaluations. Although the near-term emphasis is on current or near-future capabilities, with additional work the methods and tools should be capable of supporting evaluations of the simulated results of future systems and capabilities, including those enabled by new technologies.

1.0 INTRODUCTION

"The New Age of Space Exploration" document delineates NASA's plans to implement the President's vision for Space Exploration. The NASA Guiding National Objective number 5[1] in the document states:

> "*Study the Earth system from space and develop new space-based and related capabilities for this purpose.*"

A NASA strategic objective for FY2005 and beyond[2] support the National Objective:

> *14. Advance scientific knowledge of the Earth system through space-based observation, assimilation of new observations, and development and deployment of enabling technologies, systems, and capabilities, including those with the potential to improve future operational systems,*

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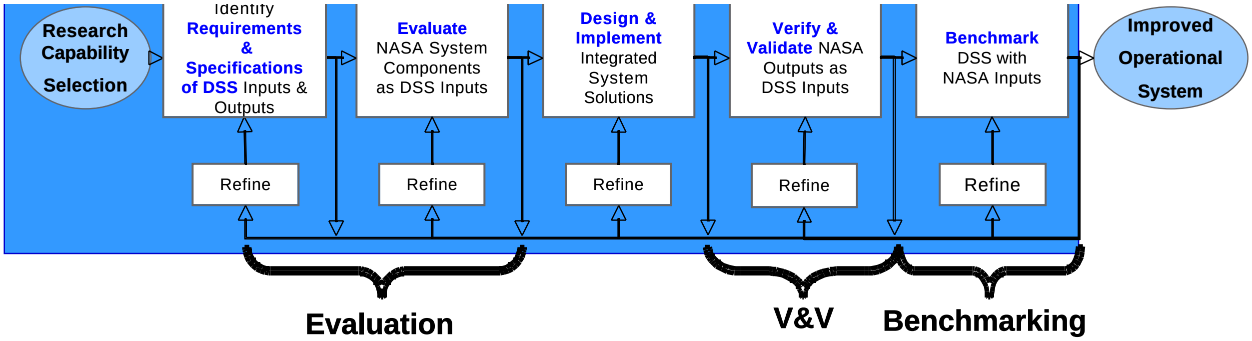
[1] The New Age of Exploration: NASA's Direction for FY 2005 and Beyond, February, 2005, NASA, page 6, http://www.nasa.gov/about/budget/index.html

[2] The New Age of Exploration: NASA's Direction for FY 2005 and Beyond, February, 2005, NASA, page 10, http://www.nasa.gov/about/budget/index.html

NASA Earth-Sun System Division of the NASA Science Mission Directorate conducts and sponsors research, collects new observations from space and develops technologies to increase knowledge of the Earth-Sun system, including its response to natural and human-induced changes, and to enable improved predictions of climate, weather, and natural hazards. It conducts and sponsors research to answer fundamental science questions about the changes seen in climate, weather, space weather, and natural hazards, and deliver sound science that helps decision-makers make informed decisions. The Division work closely with its global partners in government, industry, and the public to enhance economic security, and environmental stewardship, benefiting society in many tangible ways. NASA research and development results include 30 Earth observation spacecraft currently on orbit with nearly 100 scientific instruments acquiring measurements of key geophysical and heliophysical parameters of Earth-Sun system processes. The science data products generated from these instruments are used to study the Earth-Sun system and to enable the evolution of Earth system models to improve predictions and forecasts of weather, climate, and natural hazards to accomplish the first part of objective #14 above. The observations and predictions are also evaluated, verified and validated and benchmarked for use in improving future operational systems, pursuant to the second part of objective #14. The NASA Earth-Sun System Division is comprised of three programs: Research and Analysis Program, Flight Missions Program, and an Applied Sciences Program. The Research and Analysis Program administers the research agenda, conducts solicitations for research using NASA research Earth observation systems, and establishes roadmaps for development of spacecraft systems, data handling systems, and Earth science models needed to support the research of the Earth as a system. The Flight Missions Program administers the development of the spacecraft and data handling systems. The Applied Sciences Program administers the extension of the results of the science, models, Earth observation systems and their associated data and information products.

The Applied Sciences Program extends the results of NASA Earth-Sun system science research and knowledge beyond the science and research communities to contribute to national priority applications with societal benefits. The Applied Sciences Program employs a systems engineering approach (Figure 1), develops partnerships with operational federal agencies and national organizations, and facilitates the transition from research to operations to accomplish this goal. Applied Sciences has two primary program elements: National Applications, and Crosscutting Solutions.

NASA partners with national organizations and federal agencies to evaluate, verify and validate, and then benchmark research results that have the potential to improve future operational systems. There are two systematic approaches to accomplish this objective. One approach focuses on **solutions** that integrate Earth-Sun science observations and predictions resulting from NASA research into decision support tools of partnering organizations to benefit U.S. and global citizens. The second approach focuses on **transitioning capabilities** from research to operations through adoption or adaptation by appropriate federal agencies or national organizations.



- Use of ***Systems Engineering*** principles leads to scalable, systemic, and sustainable solutions and processes, which in turn contribute to the success of the mission, goals, and objectives of each National Application.
- The ***Evaluation*** phase involves understanding the requirements for and technical feasibility of Earth science and remote sensing tools and methods for addressing DSS needs.
- The ***Verification and Validation*** (***V&V***) phase includes measuring the performance characteristics of data, information, technologies, and/or methods, and assessing the ability of these tools to meet the requirements of the DSS.
- In the ***Benchmarking*** phase, the adoption of NASA inputs within a DSS and the resulting impacts and outcomes are documented in a Benchmark Report.

Figure 1. Systems Engineering Process used by the NASA Applied Science Program.

There are specific scientific and technological challenges associated with the tasks assigned to the Applied Science Program:

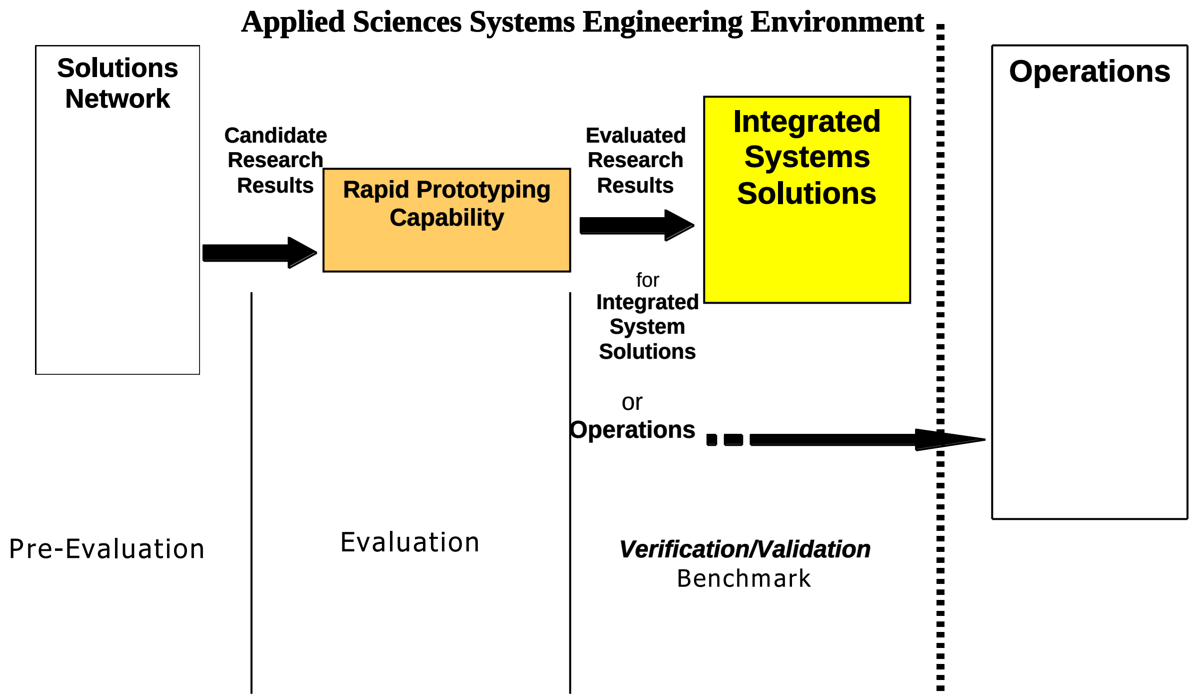
- Transitioning NASA research results to operational utilization
- Characterizing uncertainty in NASA model forecasts with respect to impacts on decision processes
- Benefiting from increasing NASA computing capacity
- Accessing NASA science data products around the globe
- Evolving a NASA Earth observations portal (gateway)
- Extending the benefits of innovative NASA R&D to address gaps in Earth observations

On an annual basis, NASA submits to Congress and the White House an Integrated Budget and Performance Document (IBPD) that specifies Agency long-term and annual performance goals for the budget. In FY 2006, the Multiyear Outcome in support of Strategic Objective #14 described above states:

14.1 Transfer 30 percent of NASA developed research results and observations to operational agencies.

The Applied Sciences Program has identified a national need for maximizing the potential products and models that could be developed from systematically evaluating innovative solutions using existing and prospective data sources and tools. To address this need and meet the long-term outcome 14.1, the Program proposes to **establish a collaborative systems engineering capacity** that

- provides tools to rapidly evaluate innovative ways of linking current and near-term observation and model output products
- demonstrates improvements for future operational systems
- provides a systematic method to extend the benefits of Earth system science research to serve society.



2.0 PURPOSE

The primary purpose of the **systems engineering capacity** is the investigation and assessment of potential uses of NASA research products, observations, and technologies to improve future operational systems by reducing the time to access, configure, and assess the efficacy of select NASA products, observations, and technologies. A systems engineering approach (as outlined in Figure 1) will be used to:

- develop a **Solutions Network** which focuses on systematically harvesting and evaluating the results of NASA research accomplished through the projects selected under Research and Analysis Program solicitations and characterizes mission and science observations and model predictions as potential candidates for operational use.[3] This approach

[3] NASA Research Announcement "Research Opportunities in Space and Earth Sciences" (NNH05ZDA001N) posted at http://nspires.nasaprs.com/ (select "Solicitations" then "Open Solicitations" then "NNH05ZDA001N").

includes improving the capacity of the network of Earth-Sun science organizations to interact and harness the results of Earth Sun science research for applications of national priority. Activities include characterizing existing organizational networks, expanding networks and adding new connections, and mining the Earth Sun science results for capacities that may address applications of national priority.

- integrate and evolve the engineering and analysis tools necessary to efficiently evaluate candidate research results, through a **rapid prototyping capability,** to further determine potential solutions for assimilation into operational decision support processes and enable the community to propose projects for feasible solutions using innovative NASA research results.
- Support the **Integrated System Solutions** activities, which focus on extending the use of NASA Earth-Sun science research results through a rigorous verification, validation, and benchmark process designed to demonstrate the potential enhanced performance of decision support tools in specific applications of national priority.

- Accommodate budget life cycle constraints. (Please refer to Figure 2)
- Enable NASA to meet its Integrated Budget and Performance Outcome described above

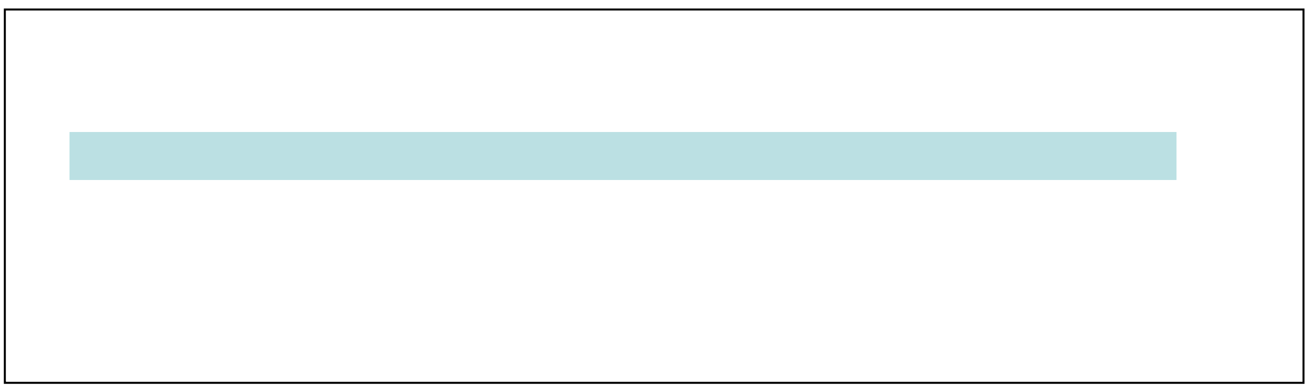


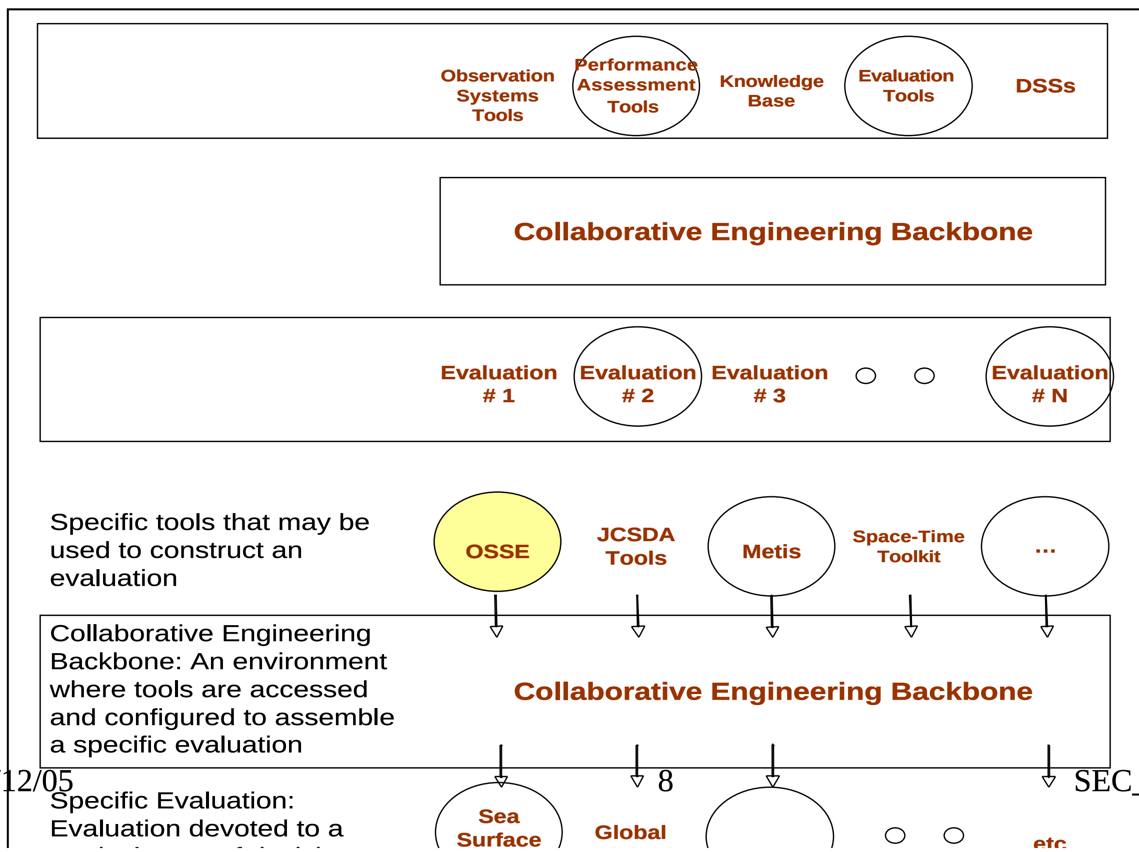
Figure 2. Comparison of traditional Research Solicitation cycle and Mission cycle. This drawing illustrates the timing issue for trying to demonstrate the utility of innovative solutions prior to initiating budget support for operational use. The most important point is that the applications community can begin to explore potential applications using Operational Spacecraft Simulation Experiment (OSSE) prior to the beginning of a mission. By using this resource, the operations communty could potentially accelerate the use of the application.

The **systems engineering capacity** will consist of a configuration of systems engineering and performance analysis tools to be used by the applied science community (i.e., NASA, other Federal agency partners, academia) to evaluate the potential of Earth Sun science research results (i.e., data, models, and algorithms). The capacity will allow implementers and users to:

- identify existing systems engineering and performance and risk assessment and analysis tools and capacities,
- capture best practices,
- develop an initial system architecture and configuration,
- test current and future capacities and configurations to enable the Applied Science Program to meet the NASA goals and objectives in a timely and rigorous manner.
- report results in a community-wide forum

The system engineering capacity will dramatically reduce the time to evaluate and assess the efficacy of *select* NASA products and technologies in candidate integrated system solutions. A successful collaborative environment can allow a user to quickly and efficiently assess the use of *current* NASA research products (data and model output) and technologies to support NASA programs, funded projects, interagency agreements, and NASA commitments to national and international programs. It will also provide the capability to rapidly assess the capacity of NASA *planned* technology to support national and international operational systems and programs. The environment shall be configured to provide:

- Integration of capacity and capability from internal and external partner organizations (e.g., OSSEs, JCSDA, SPoRT, SERVIR, ESG)
- A computer configuration with sufficient capacity to support the evaluation of any-to-all NASA research products
- Simulated sensor and data products from future NASA Earth observation systems
- Evaluation of candidate configurations of Earth-Sun System components and research products for science-based solutions
- Evaluation of candidate predictions and forecasts from Earth-Sun system models for operational utilization



3.0 CAPABILITIES

The collaborative engineering environment will provide the overall conceptual and organizational framework to build towards the optimum integration and uses of the complex and expanding set of NASA research products, models in configurations of integrated solutions to support NASA programs, NASA funded projects, NASA interagency agreements, and NASA commitments to national and international programs. The collaborative environment will be a "system of systems" consisting of current and future Earth-Sun observation systems, supplementing but not supplanting existing NASA capabilities. The environment will capture the success of Earth observation research programs, rapidly prototype and demonstrate potential use, and facilitate their transition to sustained operational use if appropriate. Joint groups, such as the Research to Operations NASA-NOAA Joint Working Group (R2O), will determine the appropriateness of transitioning capacity.

The scope of the NASA Applied Sciences collaborative engineering environment includes, but is not limited to, the functional capacity to:

- Utilize, provide, and maintain a dynamic and interactive knowledge base of current and future sources of Earth-Sun science observations, geophysical parameters, model and analysis systems, model outputs /predictions, and partnerships to extract relevant and innovative solutions

- Rapidly access and utilize data and output from Earth-Sun Science labs, Distributed Active Archive Centers (DAACs), modeling centers, Direct Satellite Downlinks, and Distribution and Handling systems

- Handle any-to-all NASA Earth-Sun System Science research results

- Benefit from and rapidly incorporate any-to-all NASA and community systems engineering tools, processes and training.

- Expand the Application Research Toolbox (ART) to support Earth viewing and imaging system requirements analysis, trade studies, and products simulation

- Utilize the National Lambda Rail network and the Project Columbia supercomputer (if this capacity and capability are needed on a case-by-case basis)

- Support any-to-all projects funded by the Applied Sciences Program

- Support tasking from R2O working groups to identify, demonstrate, and document NASA research results that can be adopted in an operational environment

- Support national and international programs and projects by using NASA's approach and results in systems for improved decision-making.

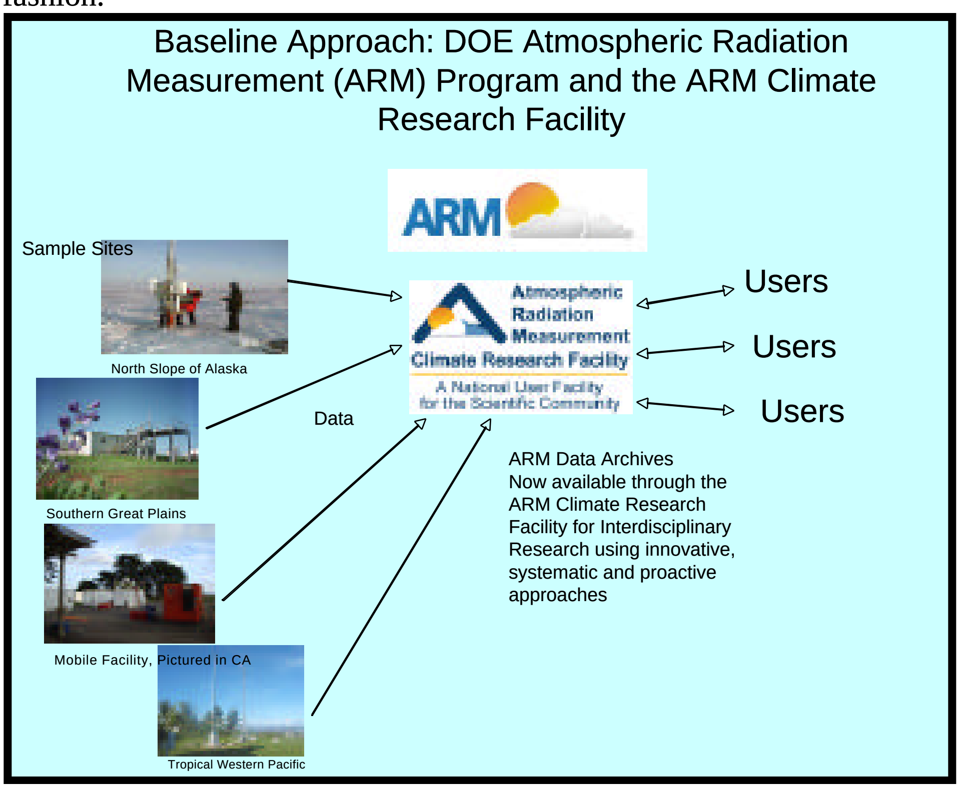
It is important to note that the scope, and hence the capabilities, of the environment will be sufficiently flexible and robust to accommodate the rapid prototyping of most, if not all, data or model product, research result, or technology from NASA and NASA's partners to assess their use in an application that benefits society. Moreover, it is envisioned that the environment will accommodate the rapid prototyping of inputs from all NASA science theme areas as they are linked to the mission of the Applied Sciences program.

4.0 APPROACH

In general, the approach that should be employed to develop the required system engineering capacity is to assemble a wide range of systems tools, organized into functional *workbenches*, that will deliver hierarchical, integrated solutions and associated assessment of performance related to the use of NASA research products and technologies. The environment will consist of centralized and distributed (virtual) components; it is recognized that the full implementation of the environment requires that the computational system, knowledge base (i.e., knowledge experts), and analytical and benchmarking workbenches will reside at, and within, multiple locations. Hence, the full collaborative engineering environment envisioned will evolve from an initial centralized system with limited external linkages to large integrated network of a base-centralized system with maximum linkages.

4.1 Capacity Building

A key element to the success of the environment is to establish a centralized base with effective linkages to a broad network of Earth science expertise, facilities, and NASA related research products and technologies. To facilitate communication and work within the network, a group of *generalized* experts, that is, across Earth-Sun science disciplines and analysis type (data vs. models), should be dedicated to working problems within the system. This cadre may reside at the centralized system, permanently or temporarily, or work in a distributed sense as long as their work is coordinated through the environment. The network will evolve to include the capacity existing within NASA programs, funded projects, interagency agreements, and NASA commitments to national and international programs. Through capacity building, a set of workbenches will be formulated, constructed, and implemented in both a centralized and distributed fashion.



4.2 Architecture -- Interoperability and Data Sharing

Computational and data sharing capacity are critical components of a successful collaborative engineering environment. The system will leverage existing NASA-sponsored computational infrastructure. For example, the environment may benefit from access to the Project Columbia supercomputer. The Project Columbia supercomputer will enable rapid complex simulations and model analysis. Also, the National Lambda Rail (NLR) project may be a key element of the CEE configuration. NLR will deliver multi-gigabits/second transfer rates between NASA centers, which will greatly enhance the types of rapid prototyping that can be accomplished. This connectivity not only will enhance access to the Project Columbia supercomputer, but will allow for rapid access to data repositories across the nation (e.g., DAACs), further adding to the capabilities to conduct rapid prototyping.

4.0 Integrated System Solutions and Research-to-Operations Transition Support

The new capacity will enable partner organizations to participate in the systems engineering approach that includes iterative testing and refinement of an enhanced prototype product. The final state of the prototype will provide an interim implementation of the enhanced product, which will allow for future verification and validation and benchmarking before end-users adopt a permanent solution. Specific projects for rapid prototyping may be selected in coordination with partners and organizations from research and operations.

The

Baseline approach: GSFC Integrated Mission Design Center

The Integrated Mission Design Center (IMDC), located at the Goddard Space Flight Center, is a human and technology resource dedicated to innovation in the development of advanced space mission design concepts to increase scientific value for NASA and its customers.

The IMDC Mission is to:
- Develop, define and design mission system concepts to support pre-formulation and formulation phase activities
- Leverage engineering expertise to provide an integrated data product in a timely and cost effective manner

The IMDC provides specific engineering analysis and services for mission design, and provides end-to-end mission design products with capabilities that include:
- Mission Studies, including System/Subsystem Concepts, Requirements, and Trades
- New Technologies & Risk Assessments
- Technical Reviews & Focused Studies

In less than 8 years of operations, the IMDC has provided mission design expertise in over 200 earth science, space science, and technology studies. Some of IMDC's past customers include:

environment will help support the systematic transition of NASA research results to operational use (R&O) by our partners through the early identification, demonstration, and documentation of NASA research results that can be adopted in the operational environment. Rapid Prototyping workbenches will enable federal agencies, such as NOAA, to select and evaluate NASA research products and technologies for operational use at a time in the NASA mission cycle that will facilitate NOAA securing the resources and capabilities necessary for R&O transition. (Figure 2)

NASA uses numerous systems to conduct research and operations. A comprehensive collaborative engineering environment will provide connectivity with these systems. Systems to be connected to the environment include, but are not limited to:

- The Knowledge Base of NASA Earth-Sun System observations, research products, and models will serve as the main information source for NASA assets within the environment.
- The Metis software system is used to organize the information with the Knowledge Base and conduct requirements analysis. METIS-based enterprise architecture (developed by other agencies and the Jet Propulsion Laboratory) may be incorporated to provide the ability to conduct Analysis of Alternative studies.
- Requirements analysis for future remote sensing instruments will be conducted using other toolsets such as the Observing System Simulation Experiments (OSSEs) and Application Research Toolbox (ART).
- Additional information on the Earth-Sun system science results provided by NASA and other organizations will be obtained through a link to the Earth-Sun Gateway (ESG) portal.

Appendix 1 provides a more extensive list of tools and capabilities that would enhance the collaborative engineering environment.

4.3 Risks and Challenges

The collaborative engineering environment project faces both programmatic and technical risks and challenges. From a programmatic perspective, the distributed architecture of the system is dependent on partner agencies and institutions for rapid response in their respective areas of expertise. In addition, fluctuations in budget and shifts in business focus may change the priorities of critical partners during a collaborative project. The organization implementing the capability will address these challenges with a senior review board consisting of NASA and partner representatives, a production team and process, a thorough systems engineering approach to implementing and operating the system, active interagency/partner working groups, and consistent alignment with stakeholder directions.

Technically, achieving and maintaining interoperability among a variety of custom and COTS system tools in an operational environment can be difficult. Both development and operational systems will be needed, with rigid configuration control and system testing programs. Keeping pace with emerging technologies and implementing them in disparate and virtual systems will also pose major challenges to the collaborative environment. However, potential solutions may exist by maintaining a close collaboration with recognized community institutions such as the OpenGIS Consortium and the Geospatial Interoperability Office. The Federation of Earth Science Information Partners (ESIP) is also a very effective network and forum for addressing interoperability issues.

5.0 **SCHEDULE**

Subject to revision

June
- Release Draft collaborative engineering environment Project Development Plan
- Stennis Space Center releases Request for Information

July
- Issue RFP
- Workshops with key enabling organizations and partners

September
- Proposals due
- Proposals evaluated

October
- Identify and select FY06 Systems Engineering projects
- Hold workshop with key FY05 RPC participants and selected FY06 RPC project teams
- Publish RPC approach and lessons learned

Appendix 1. Table of Candidate Tools and Capabilities

Name	Function	Organization	Principal
Observation System Simulator Experiments		NASA/GSFC	Bob Atlas robert.m.atlas@nasa.gov 301.614.6140
Space-Time Toolkit	The Space Time Toolkit (STT) is a Java-based toolkit that provides advanced capabilities for integrating spatially and temporally-disparate data within a highly interactive 3D display environment. Unlike most tools that require that data be converted to a common spatial and temporal grid before integration, the STT allows one to ingest swath, map-projected, station, event, or path data in whatever spatial and temporal domain in which it exists. The STT then allows the end-user to select the 2D or 3D display domain and then on-the-fly maps all data into that domain as needed. In addition to the user-selection of the spatial domain, the end-user has equal control over the aggregation and resolution of the temporal domain. http://vast.nsstc.uah.edu/SpaceTimeToolkit/	NASA/MSFC	Mike Botts mike.botts@atmos.uah.edu
Project Columbia		NASA/HQ/ARC	Tsengdar Lee tsengdar.j.lee@nasa.gov 202.358.0860
Joint Center for Satellite Data Assimilation	**Mission:** Accelerate and improve the quantitative use of research and operational satellite data in weather and climate prediction models **Goals:** *Reduce from two years to one year the average time for operational implementation of new satellite technology *Increase uses of current satellite data in NWP models *Advance the common NWP models and data assimilation infrastructure *Assess the impacts of data from advanced satellite sensors on weather and climate predictions http://www.jcsda.noaa.gov/	NASA/GSFC NOAA	John LeMarshall John.LeMarshall@noaa.gov
Short Term Prediction Research		NASA/MSFC	Steve Goodman steven.j.goodman@nasa.gov

Transition			256.961.7891
Risk Assessment Tool		JPL	David Tralli david.m.tralli@nasa.gov 818.354.1835 Verne Kaupp
Performance Assessment Tool			
Earth Sun System Gateway		NASA/GSFC	Myra Bambacus myra.j.bambacus@nasa.gov 301.286.3215
Applied Research Toolkit (ART)		NASA/SSC	Bob Ryan
STK Toolkit		Analytical Graphics	
Enterprise Architecture (Metis)		NASA/SSC/ JPL	Troy Frisbie troy.e.frisbie@nasa.gov 228.688.1989 Tony Freeman anthony.freeman-1@nasa.gov 818.354.1887
Interdisciplinary Center for Research in Earth Science Technologies (ICREST)	ICREST is the overarching Center for interdisciplinary research and development in the geographic information sciences and remote sensing (GIS/RS) area at the University of Missouri- Columbia. ICREST draws upon research faculty from the Colleges of Engineering, Arts and Sciences, and Agriculture, Food and Natural Resources, from the Graduate School and from the Office of the Vice Provost for Research to link GIS/RS technology and sustainable Decision Support Systems in Federal, state and local government for routinely providing policy information in an operational environment. http://www.icrest.missouri.edu/	University of Missouri	Verne Kaupp 573-882-0793
National Center for Atmospheric Research (NCAR)	UCAR, NCAR, and UOP are part of a collaborative community dedicated to understanding the atmosphere—the air around us—and the interconnected processes that make up the Earth system, from the ocean floor to the Sun's core. The National Center for Atmospheric Research and the UCAR Office of Programs provide research, facilities, and services for	http://www.ncar.ucar.edu/	

	the atmospheric and Earth sciences community. NCAR and UOP are managed by the nonprofit University Corporation for Atmospheric Research.		
Anderson Research Group	This experimental and theoretical laboratory performs research with scientific objectives ranging from studies of radical-molecule reactivity, to global stratospheric/tropospheric ozone chemistry, to mechanisms that control climate change. The research couples dynamics, radiation, and chemistry by developing experimental approaches for testing predictions of global-scale changes in the climate sytem. Science, engineering, and an extensive airborne field program combine to provide a union between new experimental strategies and the testing of forecast models. http://www.arp.harvard.edu/	Harvard University Anderson Research Group	Jim Anderson james_anderson@huarp.harvard.edu
Integrated Mission Design Capability	The IDC is a human and technology resource that provides rapid space system analysis and conceptual designs. Skilled engineers and scientists utilize the IDC's collaborative process and sophisticated tools to produce detailed space mission, remote sensing instrument, and/or technology applications design concepts. The IDC has two dedicated facilities where the IDC design teams and the customers collaborate in an environment that promotes rapid development and efficient trade studies of space system architectures, applications and concepts. **The Integrated Mission Design Center** (IMDC) is the mission design facility and the **Instrument Synthesis and Analysis Laboratory** (ISAL) is the instrument design facility. At the completion of a session, the design team presents its findings to the customer. Findings typically include functional systems concepts, system requirements, operational scenarios, risk areas, estimated costs, trades and assumptions, and	NASA/GSFC	Ellen Herring ellen.l.herring@nasa.gov 301.286.7393

	recommended future work. http://idc.nasa.gov/index.cfm		
DDP (Design Defect Prevention?)		NASA/GSFC?	
Knowledge Base		NASA/GSFC	Fritz Policelli fritz.policelli-2@nasa.gov
DAAC Alliance	The DAAC Alliance is the data management and user services arm of NASA's EOSDIS. The data centers process, archive, document, and distribute data from NASA's past and current Earth-observing satellites and field measurement programs. Each center serves a specific Earth science discipline. This section presents the member centers of the DAAC Alliance and gives an overview of their data holdings. The User Services Office at each center offers data products, information, services, and tools to assist data users. This section provides contact information for the User Services Office at each data center. The following table lists the DAAC Alliance data centers and their Earth science areas of expertise. http://nasadaacs.eos.nasa.gov/		Bob Chen
National LambdaRail	National LambdaRail (NLR) is a major initiative of U.S. research universities and private sector technology companies to provide a national scale infrastructure for research and experimentation in networking technologies and applications. National LambdaRail, Inc.'s (NLR) fundamental mission is to provide an enabling network infrastructure for new forms and methods for research in science, engineering, health care, and education as well as for research and development of new Internet technologies, protocols, applications and services. As evidence of the commitment to this mission, NLR will allocate 50 percent wave allocation to network research. NLR puts the control, the power, and the promise of experimental network infrastructure in the hands of our nation’s scientists and researchers. http://www.nlr.net/	Public/private collaboration	Thomas W. West, President and CEO

Grid Computing Studies for Applied Sciences			Roger Foster
IMAPP AMSR-E Level 2 Rain Rate/Rain Type software	Software converts direct broadcast binary Level 1B output files into HDF-EOS formatted Rain Rate (mm/hr) and Rain Type (Convective Rain percentage) product files. The software has been converted from the original DAAC software to run on direct broadcast input files. The output files are very similar to the files distributed by the NSIDC DAAC. Please see the http://nsidc.org/data/docs/daac/ae_rain_l2b.gd.html AMSR-E Rain Rate product web page: http://nsidc.org/data/docs/daac/ae_rain_l2b.gd.html for information on the algorithm and algorithm developers. Linux platforms 8.0, 9.0 and Enterprise are supported with this release. http://cimss.ssec.wisc.edu/~gumley/IMAPP/	University of Wisconsin-Madison	Kathleen Strabala University of Wisconsin - Madison Space Science and Engineering Center (SSEC) Cooperative Institute for Meteorological Satellite Studies (CIMSS) 1225 West Dayton Street Madison, WI 53706 Phone: (608) 263-8752 Fax: (608) 262-5974 kathy.strabala@ssec.wisc.edu

Appendix 2, Best Practices and References

Appendix 3, Potential Scenarios

Coral Reef Early Warning System (CREWS)

NOAA's Coral Reef Early Warning System (CREWS) is a network of in situ monitoring stations and a computer expert system that provide near real-time bleaching alerts for select coral reef areas.

Objectives

- At present, Coral Reef Early Warning System (CREWS) does not use any NASA Earth-Sun System observations, but three data products could be directly useful to it: **MODIS SST & IPAR,** and **QuikSCAT wind vectors**.
- Applicability of these data products to monitoring of the coral reef areas needs to be evaluated and validated by comparison of data from CREWS stations and NASA satellites.
- Correlation of CREWS observations with other NASA measurements (such as **chlorophyll concentration** and **CDOM absorption**) should be examined as well.

Approach

- Select MODIS and QuikSCAT data products for the initial comparison with CREWS observations.
- Coordinate data selection, formatting, and transfer with the NOAA personnel.
- Design prototype implementation based on reviewing results of comparisons for the provided datasets.
- Proceed with examination of the other NASA ocean measurements and propose their incorporation into CREWS when substantial correlation with *in situ* observations can be shown.

Crop Surveillance

Objectives

- Detect natural crop disease outbreaks and bio-warfare attacks
- Further relationships with DHS and USDA

Approach

- Provide High Degree of Customer Interaction
- Follow CMMI Procedures and Processes
- Use 250-m MOD13 16-day NDVI Product
- Calculate daily NDVI from 250-m MOD09 Product
- Create Movies of NDVI Images over Area of Interest
- Investigate Soybean Rust
- Team with Mississippi State University and other groups performing work in this area
- Leverage previous CDDF results

Areal Locations of Hazardous Atmospheres (ALOHA)

Objectives

- Provide real-time Areal Locations of Hazardous Atmospheres (ALOHA) model predictions to SSC
- Insert NASA provided data products into ALOHA to improve hazard predictions

Approach

- Host ALOHA and display results

- Incorporate NASA data into ALOHA and provide improved products

The “six essential ingredients” for proactive management of a collaborative system engineering environment for rapid prototyping

1. **Be proactive.** Get ready – have strategies and tools in place *before* a Mission is ready to transition to operations.

2. **Begin with the end in mind.** Appropriate objectives ensure we know where we are going – what we want to do and what we want to achieve.

3. **Put first things first**. Prioritize which potential solutions are conducive to rapid prototyping.

4. **Seek to understand** the way data, tools, and capabilities may interact to provide innovative, interdisciplinary solutions.

5. **Getting everyone involved** requires co-ordination between organizations.

6. **Sharpen the law** – contribute to the following mandates of the National Aeronautics and Space Act:

   d) The aeronautical and space activities of the United States shall be conducted so as to contribute materially to one or more of the following objectives:
   (1) The expansion of human knowledge of the Earth and of phenomena in the atmosphere and space;
   (4) The establishment of long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes;
   (5) The preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere;
   (6) The making available to agencies directly concerned with national defense of discoveries that have military value or significance, and the furnishing by such agencies, to the civilian agency established to direct and control nonmilitary aeronautical and space activities, of information as to discoveries which have value or significance to that agency;
   (7) Cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and in the peaceful application of the results thereof;
   (8) The most effective utilization of the scientific and engineering resources of the United States, with close cooperation among all interested agencies of the United States in order to avoid unnecessary duplication of effort, facilities, and equipment;

(Adapted from Popay and Timmins, Department of Conservation, Wellington, New Zealand)